Redesigning a library-based genetics class research project through instructional theory and authentic experience*

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Question: How can the library-based research project of a genetics course be reinvigorated and made sustainable without sacrificing educational integrity?

Setting: The University of Florida's Health Science Center Library provides the case study.

Methods: Since 1996, the librarian has codeveloped, supported, and graded all components of the project. In 2009, the project evolved from a single-authored paper to a group-work poster, with graded presentations hosted by the library. In 2010, students were surveyed regarding class enhancements.

Results: Responses indicated a preference for collaborative work and the poster format and suggested the changes facilitated learning. Instructors reported that the poster format more clearly documented students' understanding of genetics.

Conclusion: Results suggest project enhancements contributed to greater appreciation, understanding, and application of classroom material and offered a unique and authentic learning experience, without compromising educational integrity. The library benefitted through increased visibility as a partner in the educational mission and development of a sustainable instructional collaboration.

INTRODUCTION

In 1996, a librarian at the University of Florida's Health Science Center Libraries (HSCL) partnered with a professor from the Department of Zoology to teach general genetics, a course of approximately 120 junior and senior undergraduates (PCB3063). Together, these instructors (librarian and professor) created and implemented a term project, described in detail in 2002 [3], intended to allow students to learn more about genetics than might be possible through standard lectures and textbook readings. Students augmented these traditional methods with inquiry-based learning [4], researching an individually assigned genetic disorder by searching the literature (Online Mendelian Inheritance in Man, PubMed, Web of Science) and fact-based databases (GenBank, Structure, Entrez Gene, GeneTests), using genetic analysis tools (BLAST), evaluating and synthesizing the literature and data located through these means, writing a term paper based on these explorations, and formatting the paper using an authentic, journal house style. Such active tasks were expected to reinforce the genetics information learned and provide students with the concept of research as a scientific endeavor (''science as a verb'' [5]). The librarian provided 4 hours of hands-on database instruction and wrote and graded 3 searching assignments supporting the term project. Four years of enhanced student evaluation results suggested that students found the term project to be a useful educational experience and that it led to increased confidence in using databases and comfort in using the library [3].

However, by 2009, the cutting-edge nature of the course had been significantly reduced. The use of computers and web-based tools had become commonplace in higher education [6–8]. It is unlikely that a student in an advanced science class would have never used a computer before, as was the case with one student in 1996 [9–11]. The format of the assignment, a single-author paper, seemed out of touch with the way that students work and learn today. The benefits of collaboration and participatory work [12, 13] were not considered when the project was first conceived. The librarian's circumstances had also changed over the years, as she had become a department head with numerous administrative and other instructional responsibilities. Taking approximately fifty hours to manually grade the final term paper was no longer sustainable for the librarian. However, neither the professor nor the librarian favored ending what was considered a successful educational collaboration, and both believed that the library-based database instruction and incremental searching assignments were central to student learning. It was essential that the librarian's role in teaching about the research process not change [3]. Instead, the final work product required of students would evolve to meet the educational needs of today's science students, as well as to make assessment less time consuming. This paper describes how the final course project was enhanced through the use of instructional theory and authentic experience, decreasing the effort required to grade the final project and, therefore, facilitating the sustainability of the librarian–professor partnership.

* Based in part on a poster presented at the 10th International Congress on Medical Librarianship; Brisbane, Australia; September 3, 2009 [1]; and a poster presented at MLA '10, the 110th Annual Meeting of the Medical Library Association; Washington, DC; May 24, 2010 [2].

EC A supplemental appendix is available with the online version of this journal.

METHODS

Group work versus individual work

Modern science is often collaborative in nature, and large-scale projects such as those regarded as e-science or translational research cannot be carried out successfully without using teams with a diversity of intellect and skills [14]. Medicine is also moving toward multidisciplinary teams—physicians, nurses, medical students, residents, pharmacists, and so on—with the entire team responsible for decision making [15–18]. These are compelling reasons for giving students the opportunity to experience teamwork. Because over 90% of PCB3063 students are undergraduate science majors, with 60% to 80% planning a career in one of the health professions, PCB3063 is a perfect course for exploring such collaborative work.

The educational literature posits the virtues of collaborative learning, and much of the research on collaborative learning is founded in the social constructive learning theories, especially those of Vygotsky [13, 19, 20]. These theories propose that the range of skills developed with peer guidance exceeds that which can be achieved alone [12, 13]. Howe and Strauss's landmark work frames the characteristics of current college students known as ''millennials'' and indicates that students in this age group (19 to 25) have been working together in teams for most of their education and are comfortable working in groups [9]. However, the course instructors are not of this generation. Although they understood, in an intellectual sense, the need for students to learn to work in teams, the thought of student grades resting in part on other team members' performance gave them pause. Having experienced working on committees and team projects in their professional lives, several questions arose: Would all members of a group contribute equally? Would all students in each group learn? Would the team experience be positive for the students?

After much discussion, the instructors decided to create a hybrid system for the project. From the theoretical side, initial project work would remain based on individual work, so that students could form their own cognitive constructs (e.g., mental models [21]), with the instructors providing searching assignments as learning aids, as described by Tennant and Miyamoto in 2002 [3]. Later in the semester, students would be assigned to teams of four to complete the project and enjoy the benefits of collaborative work and social constructs, with students creating ''peer scaffolds'' (informal concept frameworks for supporting comprehension, synthesis, and application [13, 22]). In practice, students would continue to complete the sequential searching assignments individually for their assigned disorders. This would allow the students to perform searches individually, reflect on their own work, and, through these hands-on experiences, gain a greater understanding of the literature and resources, as well as become self-sufficient searchers. Each student would be separately responsible for using, exploring, and learning from the assigned databases and search assignments. Students would then be grouped into teams to develop the final project product. Team formation took into consideration student scores from the first exam and the first two searching assignments. It was expected that such assigned team building would diminish the chance that single teams would consist of all ''A'' or all ''F'' students. By working in groups designed to include a range of class performance (implying a range of knowledge of the concepts), the students could assist each other with creating scaffolds, thus increasing overall understanding of the concepts [13, 22].

Biology is messy—much is still unknown about the molecular bases of many diseases, and evidence may be contradictory prior to final confirmation. Although since the inception of the term project, the librarian has checked each disorder yearly prior to assignment to ensure that sufficient information exists for a student to tell a compelling genetic story, the details of some disorders are better understood than others, especially in the areas of protein structure and genotype/phenotype correlations [23–25]. A peripheral benefit of having students work in teams of four for the final project is that less well-understood disorders could be discarded following preliminary work. Team members would be able to teach each other about their individually assigned disorders, evaluate as a team the feasibility of using each disorder for the final project, and then choose the one that is best understood and is represented by more robust information. To facilitate this evaluation process, teams were assigned just before the third searching assignment was due. This timing allowed all students to thoroughly research their disorders and still leave enough time for the team to deliberate and decide which disorder to use for the final poster. Another major benefit of group work would be the 75% decrease in the number of final projects to grade, helping to sustain the librarian's participation.

Paper or poster?

Anecdotal comments from students showed a decided lack of enthusiasm for writing final papers, and grading more than 100 papers was burdensome. As distasteful as the instructors found replacing the paper, which had provided the students with an opportunity to practice writing, there was no alternative. It became imperative to replace writing with some other skill that would simulate the work of practicing scientists. It was decided that students would create a professional-level poster on the genetics of their assigned disorders to be formally defended in a public poster session held in the HSCL. Poster content would be similar to that in previous years when students wrote papers: the story of an assigned genetic disorder, using the information gleaned, evaluated, and synthesized through the incremental searching assignments [3].

It was expected that the ability to use text and images to describe the genetics of a particular disorder would require students to practice visual literacy in producing graphics to convey scientific concepts [26]. Although distilling the essential aspects of a genetic disorder into the terse style required of a poster could be challenging, communicating in a multi-representational mode (text and graphics [27]) is an essential part of being literate in today's society [28]. The instructors also expected that the creation and presentation of a poster would provide students with a unique and authentic learning experience, as poster presentation is a major way in which scientific research is communicated. Since the project was first envisioned in 1996, it was important to the instructors that it be constructed using the tools that practicing researchers use: online databases from the National Center for Biotechnology Information, clinical genetics resources, and the ''Instructions to Authors'' sections of journals. The creation and presentation of posters would provide a similar authentic experience, a factor in facilitating learning [29–32]. The literature of various scientific disciplines provides examples of successful undergraduate student poster presentations [33–38]. While they all have in common the creation and presentation of posters, the PCB3063 project is generally unique in its combination of class size (over 100 students), complexity (each student assigned a different topic with the need for synthesis of many resources), and level of library partnership (every stage: planning, instruction, hosting, and grading).

It was expected that most students did not have experience in the technical aspects of building posters, so the library's graphic artist provided training to the course teaching assistants (TAs). TAs and course instructors then held help sessions in the library's computer classroom and required at least one member of each team to attend. While it would have been optimal to offer help sessions that all students were required to attend, course logistics made this impossible. The professor already forfeits four hours of genetics lecture so that the librarian can provide instruction in searching and information evaluation; forgoing any additional lecture time is not possible. Following training, the HSCL's Collaboration Commons, with its group workstations and forty-eight inch monitors, became the setting of choice for students creating their posters.

Finale and feedback

The final poster presentations were held on the last day of class. All posters were exhibited in the HSCL's first-floor Collaboration Commons. Library patrons, librarians not affiliated with the course, and invited faculty viewed posters and interacted with student presenters. Two students from each team stood with the poster for the first hour of class, while their team members viewed other posters and quizzed their classmates; roles were reversed in the second hour. During the session, students were graded on their ability to explain the genetics of their assigned disorders on which the posters were based and to answer specific questions about the disorders.

Students were graded on the scientific accuracy and completeness of their responses to the questions posed by the professor, librarian, and TAs, including knowledge of genetic processes, understanding of the experiments that provided evidence as to these processes, and ways that genetics results in the observed phenotypes (15 points of poster score). During the poster session, students evaluated their teammates on a scale from 0 (did not contribute to the project) to 5 (contributed appropriately) for a total of 15 possible points. Following the session, the professor and the librarian independently graded the scientific content of the actual posters (55 points), looking for written evidence of the same criteria that students were asked to defend orally, as well as the relevance and currency of the citations used in the poster. Scores were then compared, and if there was a difference between the scores, the professor and the librarian discussed and negotiated until their scores agreed. Finally, the librarian graded citations, figures, and tables for adherence to journal house style (10 points). Overall poster point totals (95) and points from the 3 searching assignments (55) represented 25% of the total points earned in the course, equal to 1 exam.

To evaluate the changes to the final project, instructors elicited feedback from students regarding their experiences and satisfaction with the group work and poster project. In 2010, while circulating as audience, students completed the institutional review board (IRB)–approved survey (Appendix, online only) that provides the basis of the analysis in the ''Results'' section. Responses were not linked in any way to student identity and had no bearing on student grades. Students were asked to be forthcoming in their responses, as the survey was intended to provide insights that could improve the course in future semesters. The qualitative data (open-ended survey responses) were coded using an open coding approach and categorized thematically [39]. Ninety-seven students presented posters; 92 completed the survey for an overall response rate of 94.8%.

RESULTS

Objective survey results related to student perceptions of collaborative (Appendix, questions 5 and 7) and poster (Appendix, questions 6 and 8) aspects of the project are reported in Tables 1 and 2, respectively. Overall, these results support the literature regarding student preference for collaborative work [9], collaborative work as excellent learning experience [13, 19, 20, 22], and posters as an authentic learning experience [33–38]. Table 2 also illustrates student perceptions of training related to the poster (question 8). Table 3 illustrates categorized responses to open-ended questions 9–14 of the survey and details student likes and dislikes related to group work, the posters, and the project overall.

While the literature on collaborative learning [9, 12, 13] and authentic tasks such as poster creation and defense [33, 35] suggests that such methods can improve learning, the exit survey did not directly address this question. To do so would require an experimental design approach, potentially disadvantaging one group

Table 1
Student perceptions related to working in teams

Question	Respondents (n=92)	
With which statement do you most agree?		
I would rather work as part of a team than by myself	76	(82.6%)
I would rather work by myself than as part of a team	10	(10.9%)
I have no preference	6	(6.5%)
Check all that were true:		
Working in a team was more enjoyable than working on my own	76	(82.6%)
I learned more about the topic by working in a team	63	(68.5%)
Once we were assigned to teams, there was enough time left in the semester to complete the project successfully	59	(64.1%)
All of the members of the team contributed appropriately to the project	69	(75.0%)
Most of the members of the team contributed appropriately to the project	21	(22.8%)
None of the other members of the team contributed appropriately to the project	2	(2.2%)

Table 2
Student perceptions related to poster and paper formats

Question	Respondents	(n=92)
With which statement do you most agree?		
I would rather create a poster than write a paper	86	(93.5%)
I would rather write a paper than create a poster	2	(2.2%)
I have no preference	4	(4.3%)
Check all that were true:		
Creating a poster was more enjoyable than writing a paper	88	(95.7%)
I learned more about the topic by creating a poster than writing a paper	67	(72.8%)
The visuals in the poster made explanation clearer than a short paper	83	(90.2%)
Having to defend the poster made me better prepared to answer questions	77	(83.7%)
The class provided enough instruction related to building a poster	65	(70.7%)
The class provided enough instruction related to content of poster	64	(69.6%)
The class provided enough instruction related to finding information	77	(83.7%)

or the other and unlikely to pass the university's IRB or the instructors' ethical compasses. However, the instructors were impressed with the conduct of the students and the quality of the final products, as compared to the papers written in earlier semesters. They noted that graded work (content of posters and student oral defense) suggested better-prepared students, as described in the ''Discussion'' section. The instructors also reported observing less angst and more excitement about the final project than when students wrote papers and received fewer questions about the genetics of the assigned disorders than when students worked on their own. Note that it was not expected (or intended) that the course changes would result in improved information literacy skills over skills reported in 2002 [3], as no substantive changes were made to the database searching instruction.

DISCUSSION

In any discussion of instructional enhancements, it is important to consider the potential impact on the following areas: learning, classroom experience, and student and instructor satisfaction [40]. The instructional literature posits that collaborative work can enhance learning and is second nature to the students in this age group [9, 13, 19, 20, 22]. While the instructors had initially been concerned about the group work aspect of the project, survey results and observations in the class have allayed those concerns. As illustrated in Table 1, the vast majority (97.8%) of students responded that all or most of their team members contributed appropriately to the work, and 68.5% believed that they learned more through group work than they would have on their own. While respondents indicated through open-ended responses the inherent difficulties of group work (Table 3, scheduling and relying on others), most reflected on the positives of collaboration:

''It's nice because people have different strengths and with four people working on the same disease those strengths can all come together to make a well rounded poster.''

''I felt like I learned from others and learned even more by teaching others.''

''By talking about the disease, I think we all came to a better understanding of it, as opposed to just reading about the disease ourselves.''

Furthermore, most students (70.7%) thought the course provided enough instruction in creating the posters, with no significant difference between those who attended and those who did not attend the poster-building sessions (Table 2). The instructors hypothesized that the increased peer-to-peer learning is responsible for this result.

While it is not possible to unequivocally state that the changes made to the term project in 2009 and 2010 to a collaborative and poster format increased learning among the students, many responded that what they liked most about the poster and project overall was the perceived influence the assignment had on their learning. For example:

''Very good knowledge to learn and also strengthens our understanding of the course material.''

''Learning more about a specific genetic disorder, essentially compiling everything we had learned throughout the semester into a hands on project.''

''Integrative way of learning than just studying for exams or researching for a paper.''

''I liked that we can actually apply what we have learned this semester.''

Most important to the instructors, students' understanding of genetics was documented more convincingly through the posters than when students were required to write papers. Each student was responsible for publicly defending the intellectual content of the poster and answering questions about the genetics of their disorder, an activity that has been suggestive of improving performance [33, 35]. While it is relatively simple to write a class paper through regurgitation, being graded on oral answers to impromptu questions requires a greater level of

Table 3
Categorized responses to survey questions 9–14, what students liked most and least about the group work, poster, and overall aspects of the project

Group work				Poster				Overall project			
Most liked (n=86)		Least liked (n=80)		Most liked (n=87)		Least liked (n=78)		Most liked (n=83)		Least liked (n=78)	
Collaborative, diverse skills	50.0%	Scheduling	48.8%	Creative, visual nature	31.0%	Building poster	29.5%	Learned	38.6%	Nothing	23.1%
Division of labor, save time	32.6%	Relying on others	30.0%	Role in learning	24.1%	Lack of guidance	20.5%	Poster session	24.1%	Group work	11.5%
Meet new people	14.0%	Nothing	10.0%	"Real life" task	18.4%	Group work	18.4%	Group work	10.8%	Timing/research tie	10.3%

preparation for most students. In writing a brief paper, it is possible to exhibit low levels of cognition, such as knowledge (recall, recognition) and comprehension (restating, paraphrasing) [41] and still receive a passing grade. Orally defending a poster is an authentic activity, requiring higher-level cognitive tasks, such as application, synthesis, evaluation, and creation [30]—skills preferred in an upper-level undergraduate course of this nature. As noted in Table 2, 83.7% of students indicated that being required to orally defend the poster prepared them to answer questions about the genetics of their disorder. The instructors agree with this assessment.

The learning experience itself can influence student performance with, engagement with, and deep understanding of the content [40]. Assignments or experiences that seem like onerous busy work to students can severely undermine the learning process. On the other hand, authentic, unique, and exciting tasks can do the opposite, engaging them to participate in the learning process. As illustrated above, survey responses suggested that students enjoyed and preferred the course updates. In 2009 and 2010, students seemed genuinely enthused about creating the posters and working on the project. Anecdotally, students complained less about the final stages of the poster project than did students who wrote papers in previous years. In addition to the learning aspects described in previous paragraphs, students perceived the changes positively along a variety of other fronts—social, creative, and professional:

> "The poster presentation was a good end of the term way to socialize and learn about other genetic disorders."

> "The presentation in the health science library today and seeing everyone dressed up talking about their posters."

> "Helped acquire skills for later genetics research."

> "I felt like I was a professional because the poster looked like it could have been presented by a real scientist."

One student articulated how such a project can have impact beyond the undergraduate years:

> "I loved the term project experience. I feel so proud of my genetics knowledge and everything that [the instructors] taught me. I feel like a more knowledgeable, well-rounded student not only in terms of my genetics and research knowledge but more importantly how I approach academic tasks…Most of all, I treasure the experience it has given me…I'm grateful for the term project experience because I got to see a little of what it's like to be a researcher in the real world and have grown a greater appreciation for science. I can definitely say that this has been one small, yet pivotal step in my undergraduate academic experience at the University of Florida and will be a strong foundation for any future academic endeavors."

The library and the instructors also benefitted from the course changes. Holding the poster session in the HSCL has clear benefits for the library. Students enjoyed the poster session; the library made it into a true event (serving cookies and punch); and regular library clients and invited faculty were treated to an excellent academic endeavor. Such events provide evidence that the library is a true partner in the educational mission of the institution. Of lesser importance, but still consequential, moving to a team-based poster project decreased grading time, saving the librarian approximately thirty hours and the professor approximately twenty hours each semester, thus making the librarian's continued participation in the course more feasible.

Survey results revealed areas of potential improvement in course structure and administration. For example, responses to 1 objective and 2 open-ended questions indicated some students felt the 4 weeks between team assignment and poster due date was insufficient time. This finding was reinforced by the 48.8% of respondents who indicated that difficulty scheduling their groups was the aspect of the collaborative work they liked least (Table 3). To retain the advantages provided by teams composed of members with diverse knowledge levels [13], assignments are made after significant class work has been completed and graded, and it is unlikely that teams will be assigned much earlier. However, knowing that students found the time line to be a hardship will allow the instructors to emphasize the group aspects of the project and to prompt students to meet without delay upon team assignment.

The other major issue revealed related to course structure is that of students' perceived lack of guidance for the term project. Representative comments included:

> ''It was difficult at first to get started because I wasn't exactly sure what to do at first.''

> ''The vagueness about the criteria, I know that it made all of our posters very unique and gave us the freedom to put different information based on the availability of it for our disorders but sometimes it made the research kind of difficult not knowing what we needed.''

This finding was not surprising, as students reported the same feelings when the final product was a paper. A certain level of student independence is expected at the junior and senior level and is reflected in the term project requirement. The instructors believe that students are provided with sufficient instruction and assistance: each student receives a minimum of four hours of project-related instruction, with two step-by-step handouts that cover searching (how to find the information), a poster outline (what content to include in the poster), and information on where to find ''Instructions for Authors'' for the four journal house styles approved for the project. As reported from the objective survey questions (Table 2), most students believe that the course provides enough instruction in building a poster (70.7%), identifying poster content (69.6%), and finding information (83.7%), yet almost 21.0% reported the ''lack of guidance'' as the aspect they liked least about the posters. The instructors hypothesize that the unique nature of the term project—the emphasis on new information-related skills, and the need to locate, evaluate, synthesize, and integrate information—and the fact that each student is initially assigned a unique disorder requires a degree of uncertainty and places some students squarely outside their comfort zones. It is unlikely that any level of support will make some students feel comfortable with these project requirements.

CONCLUSIONS

To facilitate their continued partnership in genetics education, a professor and a medical librarian turned to instructional theory principles to preserve educational integrity, while decreasing the grading workload required for their collaboratively created term project. Taking advantage of the facts that modern science and medicine increasingly require collaboration, information skills, and visual literacy skills and that today's students enjoy collaborative work and the skills learned through authentic tasks such as poster creation and presentation, the final work product of the class term project was redesigned from a single-authored term paper into a team-based poster presentation and oral defense. Student preference for posters over papers and collaborative group work over solo work, as reported by the end-of-semester survey, reinforces findings from the literature. Both the professor and the librarian reported that students had a higher level of content understanding, evidenced by complexity and accuracy of answers to questions posed during poster defense, compared to term papers written in previous semesters. Although a definitive head-to-head comparison of the impact on student learning of the different scenarios (single-authored paper versus collaborative poster) was not possible, the quality of posters and poster presentations suggests that student learning has been not hindered by the changes in the class; indeed, available indicators suggest that student learning has been enhanced. As such, these changes are considered a viable means to teach students as well as decrease grading workload, thus contributing to the sustainability of the educational partnership between PCB3063 and the library.

As libraries continue to partner with academic faculty in the educational mission, the inclusion of instructional theory in planning new classes or enhancing existing ones can be recommended, as implementing changes tied to theory has the potential to improve the classroom experience, student and faculty perceptions, and learning. The availability of technology, such as collaboration stations for group work and ease of visualization, and provision of a public space for student assessment, such as a poster presentation, can bring the library's partnership in the educational mission into focus and make its relevance visible. However, the role of librarian extends beyond providing infrastructural resources and technical assistance. In today's academic environment, librarians continue to share their unique perspectives with faculty on what and how information is presented to their students and, thereby, how to better maximize the teaching and learning experiences in their classes. By collaborating with faculty on all aspects of a course project, as documented in this case study, librarians leverage their training and knowledge with that of the instructional faculty to provide integral connections for students and highlight the centrality of the medical library to the institutional mission.

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